

# MESOSCOPIC AND NANOSCALE SOFT CONDENSED MATTER ARCHITECTURES ON SEMICONDUCTOR SURFACES

V. Samuilov<sup>a,c</sup>, Y.-S. Seo<sup>a</sup>, V. Ksenevich<sup>c</sup>, J. Galibert<sup>b</sup>,  
J. Sokolov<sup>a</sup>, M. Rafailovich<sup>a</sup>

<sup>a</sup> Department of Materials Science, SUNY at Stony  
Brook, Stony Brook, NY 11794, USA

<sup>b</sup> Laboratoire National des Champs Magnétiques Pulsés,  
F-31432 Toulouse

<sup>c</sup> Department of Physics, State University of Belarus,  
220080, Minsk, Belarus

Soft condensed matter's most striking property is its ability to self-organize - to create spatially oriented or periodic states on nano- and mesoscopic scale [1].

(i) A novel and simple approach of self-organized fabrication of two dimensional mesoscopic networks with the feature size down to 50 nm has been developed. The technique is based on the self-organized patterning in a thin layer of complex liquid (polymer solution) in the presence of humid atmosphere. Two dimensional mesoscopic honeycomb-shaped carbon structures were produced by high temperature annealing of nitrocellulose precursors [2].

The structured polymer network was also utilized as a mask for further reactive ion etching of surfaces with epi-layer of GaAs [3,4] and GaAs/AlGaAs  $\delta$ -doped heterostructures [5]. These structures can be considered as regular arrays of mesoscopic rings or 2-D photonic band gap crystals.

The electrical transport in the obtained structures was studied in a temperature range from 1.9 to 300 K and in pulsed magnetic fields up to 35 T. A crossover from the Mott variable range hopping to the Colomb-gap Efros-Shklovskii variable range hopping has been observed experimentally in mesoscopic carbon structures [2]. At low fields,  $\ln(R/R_0)$  was proportional to  $B^2$ . In the intermediate range, the magnetoresistance was linear on B. At high temperatures, if the hopping distance is comparable to the localization length, the observed small negative magnetoresistance in our samples was consistent to the weak-localization picture. Magnetoresistance of patterned GaAs/AlGaAs  $\delta$ -doped structures was negative [5], which was related to quantum interference in hopping regime. At B=0, the resistance showed typical behavior of a two-dimensional hopping. Below about 20 K, the data followed the Mott variable-range-hopping mechanism for two dimensions.

(ii) We used diblock-copolymer system, self-assembled with L-B technique, to produce patterns at the nanometer length scale. The micellar size and intermicellar distance was found to be controlled by variation of the concentration of spreading solution and molecular weight of copolymer, which directly related to aggregation number of micelles. This structure was used as a template for introducing metal nanopatterns on semiconductor surfaces by reactive ion beam etching for magnetic storage systems [6] and DNA separation on a flat surface [7] devices.

(iii) We developed DNA molecules positioning on Si surface by simple physical alignment process. The capillary forces applied by the receding front of the evaporating drop containing DNA molecule were used to align them perpendicularly to the direction of drying front. This alignment was used as a precise DNA molecules loading technique on Si surface in a new

method of DNA separation [7]. We determined the resolution related to loading width by the thickness of the line, which was approximately equal to the length of the stretched DNA molecules.

1. T.A. Witten, Insights from soft condensed matter, Review of Modern Physics, 71, p.p. S367-S273, 1999.
2. V.A. Samuilov, J. Galibert, V.K. Ksenevich, V.J. Goldman, M. Rafailovich, J. Sokolov, I.A. Bashmakov, V.A. Dorosinets, Magnetotransport in mesoscopic carbon networks, Physica B, 294-295, p.p.319-323, 2001.
3. V.A. Samuilov, I.B. Butylina, L.V. Govor, V.K. Ksenevich, I.A. Bashmakov, I.M. Grigorieva, L.V. Solovjova, Fabrication of regular mesoscopic networks of GaAs wires, Superlattices and Microstructures, 25: (1-2) p.p.127-130, 1999.
4. V.A. Samuilov, I.B. Butylina, V.K. Ksenevich, G. Kiss, G. Remenyi, Observation of transport in mesoscopic honeycomb-shaped networks, Superlattices and Microstructures, 25: (1-2) p.p.197-202, 1999
5. J. Galibert, V.A. Samuilov, V.K. Ksenevich, M. Rafailovich, J. Sokolov, Magnetoresistance of low dimensional mesoscopic honeycomb-shape GaAs networks, Physica B, 294-295, p.p.314-318, 2001.
6. S. Zhu, R.J. Gambino, M.H. Rafailovich, J. Sokolov, S.A. Schwarz, and R.D. Gomez, "Microscopic Magnetic Characterization of Submicron Cobalt Islands Prepared Using Self-Assembled Polymer Masking Technique," IEEE Trans. Magn., **33**, 3022, 1997.
7. N. Pernodet, V. Samuilov, K. Shin, J. Sokolov, M.H. Rafailovich, D. Gersappe, B. Chu, DNA Electrophoresis on a Flat Surface, Physical Review Letters, 85, p.p.5651-5654, 2000.